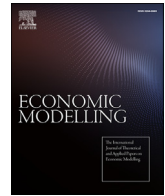




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Firm-level short selling and the local COVID-19 pandemic: Evidence from China[☆]

Jingbin He^a, Xinru Ma^{a,*}, Qu Wei^b

^a School of Management and Economics, University of Electronic Science and Technology of China, Chengdu, China

^b ICT for City Logistics and Enterprises Center, Polytechnic University of Turin (Politecnico di Torino), Turin, Italy

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ABSTRACT

Short seller trading behavior attracts much attention, especially when negative shocks occur. Recent literature has focused on the impact of the COVID-19 pandemic, an unprecedented shock, but evidence on short sellers' reactions is quite scarce. This paper investigates how short sellers responded to the local COVID-19 pandemic in China. Empirical results show that greater numbers of newly confirmed COVID-19 cases in listed firms' headquarters locations are associated with more subsequent short selling of those firms. The results hold after addressing other potential concerns. In addition, the impact of the local COVID-19 pandemic on short selling is stronger for firms with weaker financial conditions, in more vulnerable industries, and with higher risks of a stock price crash. The impact is alleviated after lifting the lockdown restrictions in Wuhan and becomes insignificant in later outbreaks. Overall, our findings support the informational role of short sellers within the context of the COVID-19 pandemic.

1. Introduction

Short sellers are recognized as informed professionals who trade and benefit from negative information (Senchack and Starks, 1993). One strand of the literature suggests that constraints on short selling impede pricing efficiency (e.g., Miller, 1977; Hong and Stein, 2003; Ofek and Richardson, 2003; Saffi and Sigurdsson, 2011). The basic idea is that short sellers incorporate more information into the stock market (Boehmer et al., 2008). Specifically, some suggest that short sellers can anticipate information and trade in advance (e.g., Christophe et al., 2004; Christophe et al., 2010; Karpoff and Lou, 2010; Feng and Chan, 2016). Some show that short sellers trade based on public information, implying that their information advantage comes from their professional ability in information analysis (Engelberg et al., 2012). Most short seller explorations are conducted at the firm level. Lynch et al. (2014) complement the existing literature by focusing on aggregated short selling and showing that short sellers possess and trade on market-wide information. Their evidence suggests a significantly positive relation between short sales in individual stocks and market- and individual-aggregated short sales (i.e., commonality in short sales); predictability of aggregated short sales on

future market returns; and predictability of aggregated short sales on future aggregated earning news, macroeconomic news announcements, and sentiment. The other strand of literature challenges the informational role of short sellers (Blau and Wade, 2012; Blau and Pinegar, 2013). For example, Chen and Singal (2003) find that speculative short selling leads to the weekend effect: stock prices rise on Fridays and decline on Mondays. Henry and Koski (2010) find no evidence to support the informational role of short sellers around seasoned equity offering (SEO) announcements, and short selling leads to reduced pricing efficiency.

During crises, clarifying the conflicting roles and concerns about short selling is important since it can help regulators develop reasonable supervision. Since short selling creates negative pressure on the stock market, regulators generally consider unbridled short selling a cause of sharp price declines. Contrarily, some studies provide evidence to support the informational role of short sellers. For example, Beber and Pagano (2013) document that constraints on short selling during the 2007–2009 financial crisis decreased liquidity and impeded price discovery. Similarly, Bohl et al. (2016) find that short-selling bans in Germany between 2008 and 2010 increased stock return volatility.

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* Corresponding author. University of Electronic Science and Technology of China, School of Management and Economics, Chengdu, China.

E-mail address: xinruma@std.uestc.edu.cn (X. Ma).

The COVID-19 pandemic, as a “once-in-a-century” pandemic, has caused an unprecedented shock to the financial market (Ding et al., 2021). Although governments have made extraordinary efforts to prevent economic depression, the baseline forecast anticipates a 5.2% tightening in global GDP.¹ Economic damage is evident, and it conveys a sense of panic to society (Nicomedes and Avila, 2020). In China, on February 3, 2020 (the first tradable day after the COVID-19 outbreak in China), the Shanghai Composite Index dropped sharply by 7.72%, the Shenzhen Composite Index dropped by 8.41%, and the Growth Enterprise Index fell by 6.85%. Among 3763 stocks, 3209 hit their daily minimum price limits, comprising 1306 stocks on the Shanghai Exchange and 1903 stocks on the Shenzhen Exchange.² Given the dramatically negative impact on financial markets led by COVID-19, prior literature on financial markets during the period has mainly documented the impact of the COVID-19 pandemic on stock returns (Ding et al., 2021), return connectedness (Bouri et al., 2021), price sensitivity (Xu et al., 2021), return predictability (Salisu and Vo, 2020), safe-haven assets (Ji et al., 2020; Akhtaruzzaman et al., 2021; He et al., 2021), and market risks (Zhang et al., 2020). Little evidence is available to detail how informed investors, such as short sellers, responded to this rare pandemic crisis.

In addition, as the COVID-19 pandemic is an exogenous proxy, it provides us with a relatively clean setting to examine how short sellers react within this context. When examining the information advantage of short sellers, a large body of literature explores the association of short selling and subsequent returns. However, reverse causality presumably exists. For example, information advantage indicates that short sellers collect information, anticipate the downtrend of stock prices, and then trade in advance. However, one possible scenario is that heavy short selling sends negative signals, similar to spreading “false rumors” or persistently attacking firms, eventually leading to poor performance (Deshmukh et al., 2015). Regarding exogeneity, factors that influence COVID-19 cases are predominantly outside the financial markets, such as population density, interprovincial movement, solar radiation (Ahmadi et al., 2020). As a result, endogeneity concerns resulting from the aforementioned reverse causality might not arise in our study since short selling is unlikely to cause changes in COVID-19 cases.

We begin by investigating the link between the local COVID-19 pandemic and short selling. We understand that Ortmann et al. (2020) also examine how the COVID-19 pandemic affects retail investors' propensity to establish a short position based on a macro and aggregated COVID-19 level. In contrast, we investigate a more micro perspective, namely, the local COVID-19 pandemic, according to the location of each listed firm's headquarters. It is intuitive since the local COVID-19 pandemic has a direct and immediate impact on locally headquartered firms. For example, to contain the local spread of the COVID-19 pandemic, local governments require community lockdowns, traffic control, stoppage of businesses such as restaurants and entertainment places, and work from home. These requirements decrease local firms' operational efficiency and economic growth. Hence, we anticipate that the number of local newly confirmed COVID-19 cases (hereafter, NCCOVID-19 cases) will have a positive impact on short selling and find supportive empirical evidence. When we expand the estimation windows of NCCOVID-19 cases from the past 1 day to the past 5 days, the results are robust.

Next, we exploit the heterogeneous effects of firm characteristics on our baseline results. First, we investigate whether financial conditions matter. The COVID-19 pandemic has greatly reduced market demand, and numerous firms have reported significant disruptions in sales activity (Meyer et al., 2021). According to Ding et al. (2021), firms with better financial conditions, such as more cash and less debt, showed better performance during the COVID-19 pandemic. We find similar results: the

relation between the local COVID-19 pandemic and short selling is alleviated in firms with less financial stress (e.g., more cash holdings and smaller increases in inventory investment), lower leverage, and lower increases in debt. Second, we focus on industries sensitive to the COVID-19 pandemic. We find that the impact of the local COVID-19 pandemic on short selling tends to be stronger in industries more vulnerable to the COVID-19 pandemic. Finally, we explore whether stock price crash risks influence the impact of the local COVID-19 pandemic on short selling. A primary explanation for stock price crash risk is managers withholding negative information due to concerns about career, compensation, or reputation (Ji et al., 2021). As a result, unprofitable projects are not canceled promptly, and their poor performance accumulates until the overvaluation bubble bursts (Bleck and Liu, 2007). Based on the above literature, we expect that the relation between the local COVID-19 pandemic and short selling tends to be more pronounced in firms with higher stock price crash risks, and empirical results support our conjecture.

Shortable stocks are not selected randomly (Hu et al., 2020), and this nonrandom nature might bias our primary findings. We adopt the Heckman two-stage model to mitigate this potential endogeneity concern and find that the positive relation between local NCCOVID-19 cases and short selling still holds. Second, considering that the COVID-19 outbreak first occurred in Wuhan (the capital of Hubei Province), our findings might only exist in Hubei Province. To alleviate this concern, we exclude firms located in Hubei Province and reestimate the relation between the local COVID-19 pandemic and short selling. The results suggest that the relation is robust in the subsample of other provinces. The third concern is that our primary result might be driven by financial reports. The sample from February to April is typically the period for financial report disclosure, such as quarterly and annual reports. Some literature demonstrates that short selling is significantly related to financial reports (e.g., Christophe et al., 2004; Blau and Pinegar, 2013). To rule out this concern, we delete months when firms disclose financial reports. The results show that the positive relation between local NCCOVID-19 cases and short selling is robust regarding the sign, magnitude, and significance.

Finally, we conduct additional analyses to assess whether our baseline results fluctuate during the subsequent events. First, we focus on the effect of lifting the lockdown restrictions in Wuhan. We find that short selling is less affected by local NCCOVID-19 cases after lifting the lockdown restrictions in Wuhan. Next, we investigate the relation between local NCCOVID-19 cases and short selling in the subsequent two outbreaks in Beijing and Xinjiang. The empirical results show that the relation between local NCCOVID-19 cases and short selling during the outbreaks in Beijing and Xinjiang becomes insignificant. It is possible as governments had accumulated considerable experience to deal with the spread of the COVID-19. The local COVID-19 pandemic was no longer a deadly threat, so short sellers became less sensitive to the local COVID-19 pandemic afterward.

The main contribution of our paper is twofold. First, our findings expand the short-selling literature from the perspective of the COVID-19 pandemic. Prior literature documents that short sellers are informed and trade via negative information, such as unprofitable dividends (Christophe et al., 2004) and negative news (Engelberg et al., 2012). However, as Rubinstein (1993) and Engelberg et al. (2012) mentioned, public news events could lead to different interpretations: agents read the same newspapers but interpret them differently. As a result, there might be a divergence in the tone of the news. The outbreak of COVID-19 allows us to use an inherently inartificial signal to examine whether short sellers trade according to this negative public information. The empirical results are consistent with the informational role of short sellers since the more severe local COVID-19 pandemic is associated with more short selling.

Second, this study contributes to the literature concerning the effect of the COVID-19 pandemic in financial markets. Answering how investors react to the COVID-19 pandemic is meaningful since it can extend

¹ <https://www.worldbank.org/en/news/feature/2020/06/08/the-global-economic-outlook-during-the-covid-19-pandemic-a-changed-world>.

² Data are from Wind database.

the contextual scope of the COVID-19 pandemic effects into financial markets. Although numerous studies focus on the impact of the COVID-19 pandemic in financial markets, evidence of investor reactions, especially short sellers, to the COVID-19 pandemic is quite sparse. This paper adds to this strand of literature in several ways. First, prior literature mainly examines the COVID-19 pandemic at a macro level (e.g., at the country level). As mentioned above, [Ortmann et al. \(2020\)](#) show that the macro COVID-19 pandemic increases retail investors' propensity to short. Instead, we start from listed firms' specific locations and focus on the impact of the local COVID-19 pandemic from a micro perspective. Intuitively, the local COVID-19 pandemic has a more direct and immediate impact on local firms' operations (e.g., local community lockdown). In addition, we further show the effects of the local, domestic, and overseas COVID-19 pandemics. The results indicate that the impact of the local COVID-19 pandemic on short selling still exists after controlling for the domestic and overseas COVID-19 pandemics. Second, prior literature has studied how short sellers react to the COVID-19 pandemic in developed countries, such as the UK ([Ortmann et al., 2020](#)). We extend by providing additional evidence in an emerging yet important market (i.e., the Chinese stock market). Third, we conduct a series of heterogeneous tests to reveal the potential mechanism of the reaction of short sellers to the local COVID-19 pandemic. Specifically, we show that short sellers' responses to the local COVID-19 pandemic are stronger in firms with poorer financial conditions, belonging to more vulnerable industries, and having higher stock price crash risks.

The rest of this study is organized as follows. In Section 2, we summarize the related literature and develop our hypotheses. Section 3 describes the data, variable construction, and summary statistics. Section 4 analyzes how short selling is influenced by local COVID-19 pandemic. Section 5 presents our conclusions.

2. Related literature and hypotheses development

Some studies indicate that short sellers might follow manipulative trading strategies and decrease price efficiency (e.g., [Goldstein and Guembel, 2008](#)). Specifically, an uninformed speculator could establish short positions to spread pessimistic information about the focal firm's investment decision. After driving down the stock prices, the speculator could cover the short positions and profit without information acquisition. As a result, the firm might abandon the project due to the negative reactions from investors, which will further reduce the firm value. Similarly, [Henry and Koski \(2010\)](#) do not find informed short selling around SEO announcements. Instead, they provide evidence of manipulative trading. [Blau and Pinegar \(2013\)](#) do not observe more short positions by short sellers before announcements but find a decline in short positions relative to those during nonannouncement periods.

Contrary to the role of manipulation, most studies highlight the informational role of short sellers, as they can facilitate information disclosure. When traders are prevented from revealing their heterogeneous information through transactions, prices may be less efficient. Specifically, the first strand of literature documents that constraints on short selling keep traders with negative information out of the markets, resulting in upward-biased prices (e.g., [Miller, 1977](#)). [Bris et al. \(2007\)](#) and [Saffi and Sigurdsson \(2011\)](#) support the view that constraints on short selling reduce price efficiency. [Chang et al. \(2014\)](#) focus on lifting short-selling bans in China and find that short-selling activities significantly facilitate price efficiency. The second strand of literature exploits abnormal short sales before events to prove the information advantage of short sellers. For example, [Christophe et al. \(2004\)](#) observe unusual levels of short sales before announcements and a negative relation between unusual short selling and subsequent returns. Similarly, [Christophe et al. \(2010\)](#) find abnormal short selling before the release of analyst downgrades. [Karpoff and Lou \(2010\)](#) focus on financial misconduct and show an abnormal increase in short interest before the disclosure of misrepresentation. The third strand of the literature reveals short sellers' information advantage based on the ability of short sales activity to predict

future stock returns (e.g., [Engelberg et al., 2012](#); [Kelley and Tetlock, 2017](#)).

Since December 2019, the COVID-19 pandemic has triggered great panic in global economic development. A strand of literature has explored the effect of the COVID-19 pandemic on stock markets. Extensive evidence suggests that the COVID-19 pandemic leads to poor stock performance (e.g., [Salisu and Vo, 2020](#); [Xiong et al., 2020](#); [Ding et al., 2021](#); [Ftiti et al., 2021](#); [Xu, 2021](#)). For instance, [Ding et al. \(2021\)](#) provide international evidence on characteristics that make firms' returns less sensitive to the COVID-19 pandemic. [Ftiti et al. \(2021\)](#) stress that the COVID-19 pandemic diffuses pessimistic information, exacerbates return volatility, and increases liquidity risk. Some studies investigate the safe-haven assets during the COVID-19 pandemic (e.g., [Conlon and McGee, 2020](#); [He et al., 2021](#)). Specifically, [He et al. \(2021\)](#) provide evidence on whether US Treasuries are safe-haven assets during the COVID-19 pandemic. Their model predicts positive Treasury inconvenience yields, which is also supported by empirical evidence. [Conlon and McGee \(2020\)](#) explored whether Bitcoin can be deemed a safe-haven asset but found no supportive evidence.

Due to the severely negative impact of the COVID-19 pandemic, many countries paid close attention to short selling. An important question is how short sellers react to this pandemic. Using data from a UK broker, [Ortmann et al. \(2020\)](#) explore investors' propensity to short based on the macro COVID-19 pandemic level. [Kizys et al. \(2021\)](#) observe herding behavior during the COVID-19 pandemic and indicate that constraints on short selling alleviate herding behavior. Unlike previous work mainly based on country-level COVID-19 cases (i.e., macro COVID-19 environment), we aim to answer how the COVID-19 pandemic in the province where a listed firm is located influences its short selling.

On the one hand, the local COVID-19 pandemic directly impedes the economic development of local firms as firm growth relies on the local business environment. When the local COVID-19 pandemic is severe, it directly disrupts corporate operations due to the local community lockdown and restriction policies ([Chen et al., 2021](#)). For example, [Walker and Hurley \(2021\)](#) find that local lockdowns impede business activities. Specifically, they show that the turnover growth of small- and medium-sized enterprises up to 2 km inside the lockdown boundaries is eight percentage points lower than those up to 2 km outside. Moreover, compared with other countries, the community lockdown policy implemented in China is deemed quite prompt and strict. Local governments require businesses such as entertainment places and restaurants to halt operations and forbid citizens from going outside unless necessary (e.g., buy groceries and other necessities). Ultimately, the policy is proven effective but at tremendous economic and social costs ([Mei, 2020](#)). For example, to comply with local policy on the COVID-19 pandemic, Shanghai Disneyland was closed, which might lead to a drop in operating income by approximately \$135 million.³ On the other hand, firms have to cover additional costs to ensure the health of employees and the safety of products. For example, [Barman et al. \(2021\)](#) show that firms need to adopt measures to improve working conditions and maintain employees' health and safety during the COVID-19 pandemic. That is, firms need to spend considerable time and effort to avoid its spread within the firm. If short sellers can acquire the negative information related to local firms' development and incorporate it into trades, we expect to observe a positive relation between short selling and the local COVID-19 pandemic.

Furthermore, previous literature on home biases also indicates that investors prefer locally headquartered stocks and trade based on information advantage ([Coval and Moskowitz, 1999](#); [Ivković and Weisbenner, 2005](#)). For example, [French and Poterba \(1991\)](#) show that most investors invest almost all their wealth into local assets rather than overseas assets even though international diversification could benefit significantly. [Coval and Moskowitz \(1999\)](#) demonstrate investors' preferences for

³ <https://edition.cnn.com/2020/02/05/business/disney-shanghai-hong-kong-parks-coronavirus/index.html>.

geographic proximity among domestic stocks (i.e., holding local stocks). Ivković and Weisbenner (2005) also show the locality biases when households make investment decisions. Wu et al. (2018) find that air pollution depresses local investors, which further induces lower stock returns of locally headquartered firms. Driven by this strand of literature, if short sellers tend to trade on locally headquartered stocks, they experience the local community lockdowns themselves when the local COVID-19 pandemic is severe, and thus, they acquire negative information more directly. Taken together, we propose the following hypothesis based on the above discussions:

H1. Short selling is positively related to the local COVID-19 pandemic.

We then attempt to discuss some of the firm characteristics that might have effects on H1. First, the COVID-19 pandemic has an immense impact on the supply chains, and products experience a sharp reduction in market demand (Ivanov and Dolgui, 2020). As a result, related firms suffer from considerable cancelation of orders and payment withholding (Paul et al., 2021). This indicates that the COVID-19 pandemic causes great pressure on firms' financial conditions. Consistent with this view, Ding et al. (2021) explore the effect of financial conditions during the COVID-19 pandemic and find that firms with more cash and less debt tend to be less influenced by the COVID-19 pandemic. Therefore, we expect that firms with greater financial stress (i.e., less cash, more inventory increase) and more debt suffer more from the local COVID-19 pandemic. As a result, the reactions of short sellers on this firm to the local COVID-19 pandemic should be stronger.

Second, previous literature has shown that not all industries are severely influenced by the COVID-19 pandemic. For example, Ivanov and Dolgui (2020) mention that industries related to facial masks and disinfection spray experience a dramatic increase in market demand. However, industries related to tourism suffer from a sharp decrease. Fotiadis et al. (2021) indicate that tourist arrivals drop by approximately 30.8%–76.3%. Based on these studies, a natural conjecture is that the short sellers react to the local COVID-19 pandemic is stronger in industries that are more vulnerable to the COVID-19 pandemic.

Finally, among the firm characteristics, stock price crash risk is deemed a consequence of managers' bad information hoarding from investors. Once it comes to the threshold, stock prices crash (Li et al., 2017). As a result, investors show great concerns about the actual prospects of those firms. For example, Kim et al. (2011) highlight that tax avoidance withholds negative information, resulting in the stock price crash. The accounting scandal from Olympus caused the stock price to drop by approximately 70% in three weeks (An et al., 2015). Callen and Fang (2015) link short selling with crash risks and propose that short sellers could detect the hoarding of negative information. Based on the literature, we expect that the higher the stock price crash risk a firm has, the more short sales there are of this firm in response to the local COVID-19 pandemic. Taken together, we propose the following hypothesis:

H2. The positive relation between short selling and local COVID-19 pandemic in H1 is more pronounced in firms with poorer financial conditions, belonging to more vulnerable industries, and having higher stock price crash risks.

3. Data, sample, variables

Our dataset comprises two parts: daily COVID-19 cases and short selling. In the following subsections, we describe the data sources and main variable construction. In Appendix A, we also summarize the detailed definitions of all variables in the following analyses.

The sample period for baseline analysis is from February 10, 2020, to April 14, 2020. Short selling in China has been limited since February 3, 2020. Specifically, the rapid spread of the COVID-19 pandemic in January 2020 led to a sharp fall in the stock market. To stabilize the market, the China Securities Regulatory Commissions (CSRC) issued a

verbal directive to limit short selling. Then, we observe a significant recovery on February 10, 2020.⁴ On April 15, China shut down the largest makeshift hospitals (i.e., Leishenshan and Huoshenshan hospitals) in Wuhan.⁵ Hence, we use this sample period to primarily emphasize the impact of the COVID-19 pandemic on short selling.

3.1. COVID-19 pandemic

The COVID-19 data are obtained from the China Stock Market and Accounting Research (CSMAR) database. This province-level dataset includes the date, province name, and the cumulative number of confirmed cases. In the spirit of Ding et al. (2021), we use the daily newly confirmed COVID-19 cases to measure the pandemic. Specifically, the variable of interest, *Local_COVID19*, is constructed as follows:

$$Local_COVID19_rd_{i,t-1} = \log(1 + LocalCases_{i,t-1} - LocalCases_{i,t-1-\tau}) \quad (1)$$

Where, *Local_COVID19_rdt-1* is the newly confirmed COVID-19 cases in the province where firm *i*'s headquarters is located from day $t-1-\tau$ to day $t-1$ ($\tau = 1, 5$). *LocalCases_{i,t-1}* is the number of cumulative confirmed COVID-19 cases on day $t-1$ in the province where firm *i*'s headquarters is located. In addition, we also collect domestic and overseas COVID-19 data from the CSMAR database, including the date and aggregated domestic and overseas cumulative number of daily confirmed cases.

3.2. Short sales and stock market

Information on short sales and the stock market also comes from CSMAR. It generally contains the stock code, the date, the short volume, stock trading volume, trading value, stock return, the highest and lowest prices, and the headquarters' location of each firm. Following Diether et al. (2009) and Engelberg et al. (2012), we construct the short ratio as follows:

$$ShortRatio_{i,t} = \frac{ShortVol_{i,t}}{TotalVol_{i,t}} \quad (2)$$

Where, *ShortRatio_{i,t}* is the relative short ratio of stock *i* on day *t*. *ShortVol_{i,t}* is the short volume of stock *i* on day *t*. *TotalVol_{i,t}* is the stock trading volume of stock *i* on day *t*. The headquarters location information of each firm allows us to link the short-selling data with COVID-19 data.

Prior literature usually refers to the S&P 500 volatility index (hereafter, VIX) provided by the Chicago Board Options Exchange as the investor fear gauge (e.g., Whaley, 2000; Longstaff, 2010). Some document that VIX is not simply a proxy for investor fear in the US market but also for China (e.g., Sarwar, 2012; Wang and Lee, 2012). Since the COVID-19 pandemic exacerbates uncertainties and increases investor fear and pessimism, we follow Liu et al. (2020) and collect VIX data from the website of the Chicago Board Options Exchange.⁶

3.3. Summary statistics

Table 1 presents the sample distribution by province. Among 73,111 observations, 15.3% of the observations are associated with firms in Guangdong, and 10.68% of the observations are related to firms in Beijing. The proportions of observations from other provinces are below 10%. For short selling, the average values of the short-selling ratio are over 0.4% only in Heilongjiang, Shaanxi, Tianjin, Shanghai, and Beijing. The average number of daily confirmed COVID-19 cases in Hubei Province is the largest in our sample period, approximately 740.2 due to the

⁴ Related data of short selling trend is from Wind database.

⁵ http://english.www.gov.cn/news/videos/202004/15/content_WS5e96bd3bc6d0c201c2cc0fa0.html.

⁶ https://www.cboe.com/tradable_products/vix/vix_historical_data/.

Table 1
Sample distribution.

Province	Number of firm-day observations	Fraction of observations	Average ShortRatio (%)	Average No. of New confirmed cases
Anhui	2300	3.146%	0.177	3.022
Beijing	7805	10.676%	0.462	4.402
Chongqing	1287	1.760%	0.186	2.002
Fujian	2803	3.834%	0.192	1.560
Gansu	673	0.921%	0.137	0.892
Guangdong	11,189	15.304%	0.325	6.922
Guangxi	541	0.740%	0.089	0.861
Guizhou	690	0.944%	0.225	0.739
Hainan	735	1.005%	0.244	0.697
Hebei	1373	1.878%	0.196	2.032
Heilongjiang	683	0.934%	0.444	7.575
Henan	1564	2.139%	0.251	3.630
Hubei	2417	3.306%	0.246	740.174
Hunan	1979	2.707%	0.208	2.868
Inner Mongolia	690	0.944%	0.258	1.870
Jiangsu	6806	9.309%	0.356	2.859
Jiangxi	1149	1.572%	0.167	3.198
Jilin	873	1.194%	0.337	0.347
Liaoning	1494	2.043%	0.380	0.566
Ningxia	92	0.126%	0.017	0.543
Qinghai	176	0.241%	0.225	0.000
Shaanxi	1012	1.384%	0.448	0.913
Shandong	4536	6.204%	0.271	6.545
Shanghai	6534	8.937%	0.459	4.494
Shanxi	736	1.007%	0.255	1.348
Sichuan	2297	3.142%	0.205	2.666
Tianjin	1191	1.629%	0.501	1.678
Tibet	308	0.421%	0.093	0.000
Xinjiang	1139	1.558%	0.271	0.483
Yunnan	782	1.070%	0.134	0.870
Zhejiang	7257	9.926%	0.290	3.067
Total or average	73,111	100%	0.315	28.099

This table reports sample distribution, the average short ratio, and the average No. of confirmed cases by province. Specifically, our sample covers 31 provincial administrative units in China.

outbreak in Wuhan. On average, Beijing, Shanghai, Guangdong, Shandong, and Heilongjiang have more than four confirmed COVID-19 cases per day.

Table 2 shows the summary statistics for all variables used in the following analyses. We winsorize all variables at 1% in both tails to limit the influence of outliers. On average, the number of NCCOVID-19 cases (natural logarithm) in the past one day before short selling is approximately 0.952 (*Local_COVID19_1d*). We also find sufficient variation since the 5th percentile equals zero and the 95th percentile equals 3.219. We

Table 2
Summary statistics of variables.

Variable	N	Mean	SD	P5	P25	Median	P75	P95
ShortRatio	73,111	0.300	0.628	0.000	0.000	0.044	0.287	1.584
Local_COVID19_1d	73,111	0.952	1.191	0.000	0.000	0.693	1.609	3.219
Local_COVID19_5d	73,111	2.081	1.728	0.000	0.693	1.946	3.296	5.024
Domestic_COVID_1d	73,111	5.220	1.667	3.296	4.331	4.745	6.250	7.884
Domestic_COVID_5d	73,111	7.084	1.607	4.913	5.927	6.354	8.041	10.138
Overseas_COVID_1d	73,111	8.155	2.714	3.829	5.911	8.782	10.949	11.229
Overseas_COVID_5d	73,111	9.606	2.708	5.176	7.187	10.027	12.191	12.862
Turnover	73,111	3.141	3.555	0.322	0.888	1.841	3.966	10.588
StockReturn	73,111	0.096	1.514	-2.365	-0.857	0.077	0.959	2.683
Illiquidity	73,111	0.021	0.022	0.002	0.007	0.014	0.027	0.066
PriceRange	73,111	4.489	1.891	1.955	3.039	4.177	5.635	8.134
VIX	73,111	41.517	20.407	14.144	17.376	42.912	60.222	72.976
MktVolatility	73,111	0.020	0.002	0.015	0.018	0.020	0.022	0.022

This table reports summary statistics of variables in this paper. For each variable, “N” represents the number of observations, “Mean” represents the equal-weighted mean value, “Median” represents the median value, “SD” represents its standard deviation, and “PX” represents the Xth percentile of its distribution.

then expand the estimation window from one day to five days. On average, *Local_COVID19_5d* is 2.081. The increasing trend among different windows is intuitive since a longer estimation window generally indicates more NCCOVID-19 cases. We also find a similar trend in the standard deviations. For the independent variable of interest, the mean value of the short ratio is approximately 0.300%. Considering that the short-selling ratio in 2017 in China equals 0.204% (Hu and Chi, 2019), the short-selling level in our sample period is relatively higher than that in normal situations. It is sensible since the pandemic impairs economic development and leads to depression, resulting in more short selling activity.

In terms of control variables, we include domestic and overseas NCCOVID-19 cases. Specifically, the average number of domestic NCCOVID-19 cases in the past one day (five days) is approximately 5.220 (7.084), and the average number of overseas NCCOVID-19 cases in the past one day (five days) is approximately 8.155 (9.606). In addition, the average turnover equals 3.141%, and the average daily stock return in the past five days is approximately zero. The mean value of illiquidity equals 0.021, and the intraday price range equals 4.489 on average. The average VIX equals approximately 41.517, and the market volatility equals 0.020. Overall, our sample seems well-balanced.

4. Empirical results

4.1. Short sellers' reactions to the local COVID-19 pandemic

In this section, we investigate whether the local COVID-19 pandemic influences short selling. To answer this question, we use the following regression model:

$$ShortRatio_{i,t} = \alpha + \beta_1 \times Local_COVID19_rd_{i,t-1} + \sum \beta_\gamma \times Control_\gamma + FE_s + \varepsilon_{i,t} \quad (3)$$

Where, *Local_COVID19_rd_{i,t-1}* is the natural logarithm of (1 + the number of NCCOVID-19 cases in the province where the headquarters of firm *i* is located in the past τ days) ($\tau = 1, 5$). *Control_γ* are the control variables. To test our conjecture, we include stock-month fixed effects to control for unobservable time-variant firm-level characteristics, such as local average weather conditions, regulations, and policies (e.g., Klose and Tillmann, 2021). Notably, stock-month fixed effects can absorb stock fixed effects and month fixed effects. Therefore, this pair of fixed effects can also control for unobservable monthly (time-series) factors and time-invariant firm-level characteristics, such as some fundamental information. Weekday fixed effects are included to control for the potential weekend effect (French, 1980). In addition, we include a time trend variable to control for the time-series trend of COVID-19 cases, which could help us alleviate the impact of time-series predictability on COVID-19 cases.

When estimating the regression model, we mainly use two specifications. In the first specification, we only include fixed effects without specific control variables to explore the impact of the local COVID-19 pandemic on short selling. In the second specification, we additionally include domestic and overseas aggregated NCCCOVID-19 cases, firm-day level control variables, VIX, and market volatility. Specifically, we include domestic NCCCOVID-19 cases (*Domestic_COVID19*) and overseas NCCCOVID-19 cases (*Overseas_COVID19*) in our regression model to control for the impact of nationwide and global-level COVID-19 pandemics. Following the previous literature on short selling (e.g., [Blau and Wade, 2012](#); [Blau and Pinegar, 2013](#); [Chang et al., 2014](#); [Hu and Chi, 2019](#)), we include past short ratio to control for the time-series autocorrelation in short selling (*Lagged_ShortRatio*) and also add turnover (*Turnover*), past average stock return (*StockReturn*), illiquidity (*Illiquidity*), and intraday price range (*PriceRange*) as control variables. In addition, [Liu et al. \(2020\)](#) has shown that the COVID-19 pandemic had raised investors' fear of uncertainty at the beginning of the pandemic. To control for investors' fear, we follow [Liu et al. \(2020\)](#) and include *VIX* in our regressions. In addition, we include *MktVolatility* to control for stock market volatility. Variables are defined in detail in [Appendix A](#). The *t*-statistics are

Table 3
Short sales in response to local COVID-19 pandemic.

Dependent variable =	<i>ShortRatio</i>			
	(1)	(2)	(3)	(4)
<i>Local_COVID19_1d</i>	0.018*** (8.64)	0.016*** (6.72)		
<i>Local_COVID19_5d</i>			0.014*** (8.31)	0.010*** (4.76)
<i>Domestic_COVID_1d</i>		−0.000 (−0.20)		
<i>Overseas_COVID_1d</i>		−0.004 (−1.06)		
<i>Domestic_COVID_5d</i>				0.009*** (3.02)
<i>Overseas_COVID_5d</i>				−0.003 (−0.34)
<i>Lagged_ShortRatio</i>		0.158*** (5.70)		0.156*** (5.61)
<i>Turnover</i>		0.003 (1.55)		0.003 (1.53)
<i>StockReturn</i>		−0.009*** (−6.55)		−0.009*** (−6.73)
<i>Illiquidity</i>		0.058 (0.86)		0.054 (0.78)
<i>PriceRange</i>		−0.006*** (−2.71)		−0.005** (−2.11)
<i>VIX</i>		0.001 (1.56)		0.001** (2.29)
<i>MktVolatility</i>		2.642*** (3.02)		1.354 (1.63)
Stock-month fixed effects	Yes	Yes	Yes	Yes
Weekday fixed effects	Yes	Yes	Yes	Yes
Time trend	Yes	Yes	Yes	Yes
Number of obs.	73,109	73,109	73,109	73,109
Adjusted R-squared	0.712	0.714	0.712	0.714

This table presents how the COVID-19 pandemic in the province where a firm's headquarters is located affects short selling. The sample period in this table is from February 10, 2020, to April 14, 2020. The dependent variable (*ShortRatio*) is each firm's short selling volume divided by total trading volume on day *t*. *Local_COVID19_1d* and *Local_COVID19_5d* denote the natural logarithm of one plus the number of newly confirmed local COVID-19 cases in the province of the firm's headquarters in the past one day and five days, respectively. We control for stock-month fixed effects, weekday fixed effects, and time trend in all specifications. In Columns (2) and (4), we add a series of control variables related to stock market trading activities. Variable definitions are available in [Appendix A](#). The *t*-statistics are calculated with standard errors clustered at the firm level and reported below the regression coefficients in parentheses. We use ***, **, and * to denote significance at the 1%, 5%, and 10% levels, respectively (The same for the following regressions hereafter).

calculated with standard errors clustered at the firm level.

Results are shown in [Table 3](#). In Column (1), we find that the coefficient on NCCCOVID-19 cases in the past one day (*Local_COVID19_1d*) is positive and statistically significant at the 1% level. This result indicates a significant impact of the local COVID-19 pandemic on short selling. Short sellers will short the stocks of firms involved in the severe COVID-19 pandemic due to unfavorable signals, such as pessimistic expectations of the economy. In Column (2), we include additional control variables. The coefficient on *Local_COVID19_1d* equals 0.016, which is statistically significant at the 1% level. It indicates that a one-standard-deviation increase in *Local_COVID19_1d* leads to an increase of approximately 6.4% of the average short ratio for the sample overall ($=0.016 \times 1.191 / 0.3$). The coefficients on domestic and overseas NCCCOVID-19 cases are both insignificant. For other control variables, we observe the momentum of short selling since the relation between past and current short ratios is positive, consistent with previous findings (e.g., [Blau and Wade, 2012](#); [Chang et al., 2014](#)). We also observe a significantly negative relation between past average stock returns and short ratios. It indicates that previous stock performance is also significantly associated with subsequent short selling, similar to the findings in [Blau and Pinegar \(2013\)](#). As for the adjusted R-square, it equals 0.714 and is comparable to previous literature, such as [Blau and Wade \(2012\)](#). In Columns (3) and (4), we expand the estimation window for local NCCCOVID-19 cases to five days and find similar results. The coefficient on *Local_COVID19_5d* equals 0.014 in Column (3) and 0.010 in Column (4), still significant at the 1% level. It suggests that a one-standard-deviation increase in *Local_COVID19_5d* increases the short ratio by approximately 5.8% ($=0.010 \times 1.728 / 0.3$).

A potential concern about the standard errors is that they might be correlated at the province level. To mitigate this concern, we also report regression results based on standard errors clustered at the province level in [Appendix B](#). All specifications are the same as those in [Table 3](#). Empirical results show that the coefficient on *Local_COVID19* in all estimation windows and specifications is positive and statistically significant at the 1% level. These findings are consistent with [Table 3](#), suggesting that the relation between the local COVID-19 pandemic and short selling is robust.

Collectively, the results in this section provide strong evidence that short sellers trade in response to the local COVID-19 pandemic. The effect of domestic and overseas COVID-19 might exist but not be that prominent and robust in our sample period. It is intuitive since a firm's daily operation is highly related to the local pandemic. For example, to contain the worsening COVID-19 pandemic, local governments would voluntarily determine whether to lock down certain communities. Restrictions induced by a large number of infected cases in daily life and work undoubtedly raise investors' concerns about an increase in the unemployment rate and a decrease in economic growth. Hence, larger local NCCCOVID-19 cases will lead to larger short selling.

4.2. Heterogeneity of short sales in response to the local COVID-19 pandemic

In this section, we conduct cross-sectional analyses to enrich our understanding of the potential mechanism of our baseline results. First, we focus on firms' prior financial conditions to verify their influence. Second, we examine whether the relation between local COVID-19 pandemic and short selling is more pronounced in firms in vulnerable industries. Third, we explore whether firms' stock price crash risks influence the impact of the local COVID-19 pandemic on short selling.

4.2.1. Financial conditions

This subsection explores the impact of firms' pre-pandemic financial conditions on our primary findings. The COVID-19 pandemic reduces market demand, and the sharp reduction in sales and redundant inventories will raise inventory-related costs. Based on this point of view, firms with sufficient cash holdings might face less pressure to cover the

costs and maintain daily corporate operations. To verify this conjecture, we introduce cash holding ratio and increase in inventory investment as interaction variables in our baseline regressions. Specifically, we follow prior literature (e.g., Ding et al., 2021) to construct the cash holding ratio (*CashRatio*), which equals the cash and cash equivalents divided by the total assets reported in the 2019 annual report of each listed firm. In the spirit of Thomas and Zhang (2002), we also construct the increase in inventory investment (*InventoryIncrease*), which equals the change in inventory scaled by total assets reported in the 2019 annual report. We include the two variables, cash holding ratio and the increase in inventory investment, as interaction variables in our baseline regressions and normalize *CashRatio* and *InventoryIncrease* by subtracting the sample mean and dividing the difference by the in-sample standard deviation.⁷

Table 4 shows the regression results. All specifications are consistent with Table 3. For conciseness, we do not report coefficients on control variables because they are similar to those in Table 3. *Independent* represents *Local_COVID19_1d* in Columns (1) to (2) and *Local_COVID19_5d* in Columns (3) to (4) hereafter. We begin by investigating the impact of cash holdings in Panel A. We find that the coefficient on *Independent*CashRatio* is negative and statistically significant across all specifications and estimation windows. This indicates that the relation between the local COVID-19 pandemic and short selling is less pronounced in firms with more sufficient cash holdings. Specifically, we repeat our regression in Columns (2) and (4) in the saturated specification. The results indicate that the relation between the local COVID-19 pandemic and short selling tends to be 42.9%⁸ weaker in firms with a one-standard-deviation increase in the cash ratio from the sample mean compared with firms equal to the sample mean in Column (2) and 44.4% weaker in Column (4). In Panel B, we use an increase in inventory investment as a proxy for prior-pandemic capital occupation. The results show that the coefficient on *Independent*InventoryIncrease* is positive and statistically significant at the 5% level. With the inclusion of all controls in Columns (2) and (4), the association between the local COVID-19 pandemic in the past one day (five days) and short selling is 33.3% (44.4%) stronger in firms with a one-standard-deviation increase in inventory investment from the sample mean relative to those equal to the sample mean.

Next, we investigate whether debt affects the relation between the local COVID-19 pandemic and short selling. Debt is generally linked to financial risk and constraints (Allayannis et al., 2003). Higher levered firms might have larger employment losses during the recession (Giroud and Mueller, 2017). Based on this, we propose that reactions of short sellers to the local COVID-19 pandemic tend to be stronger in those firms. We use two variables to measure a firm's debt condition: leverage and growth in debt (Bowman, 1980; Bhandari, 1988; Richardson et al., 2005).

Results are reported in Table 5. In Panel A, we use the normalized variable *Leverage* to construct the interaction term. We find that the coefficient on *Independent*Leverage* is statistically positive in all columns, indicating that leverage could prominently exacerbate the relation between the local COVID-19 pandemic and short selling. In our favored (saturated) specification in Columns (2) and (4), a one-standard-deviation increase in leverage from the sample mean increases the association between the local COVID-19 pandemic and short selling by approximately 42.9% and 33.3%. In Panel B, we focus on the increase in debt before the COVID-19 outbreak. We find that the coefficient on *Independent*DebtGrowth* is also positive and significant at the 5% level in all specifications. It suggests that the influence of the local COVID-19 pandemic in the past one day (five days) with full controls is 40.0%

(40.0%) more pronounced in firms with debt growth one standard deviation above the sample mean compared with firms equal to the sample mean.

4.2.2. Vulnerable industries

This subsection investigates whether the short selling of firms in vulnerable industries is further influenced by the local COVID-19 pandemic. According to Xiong et al. (2020), we define an industry as vulnerable if the industry is related to transportation and postal warehouse, food, hotel and tourism, real estate, video entertainment, and construction. Results are presented in Table 6. We find that the coefficient on *Local_COVID19* is positive and significant at the 1% level. For the interaction term of vulnerable industries (*VulnerableInd*) and the local COVID-19 pandemic (*Local_COVID19*), the coefficient varies from 0.017 to 0.032 and is statistically significant at the 1% level across all four columns. Overall, the results show consistent evidence that the impact of the local COVID-19 pandemic on short selling is relatively widespread since the short selling of firms in vulnerable and less vulnerable industries is influenced by the local COVID-19 pandemic. Furthermore, consistent with our expectation, the relation between local COVID-19 pandemic and short selling is more pronounced in firms listed in industries vulnerable to the local COVID-19 pandemic.

4.2.3. Stock price crash risks

As stock price crash risk is generally deemed a consequence of the concealment of negative information, we explore whether stock price crash risks in 2019 will aggravate the relation between the local COVID-19 pandemic and short selling. In the spirit of prior literature, we construct two measures for stock price crash risks based on down-to-up volatility (*CrashDownUp*) and skewness (*CrashSkewness*) of a focal firm's weekly returns (e.g., Chen et al., 2001; Kim et al., 2011; Ma et al., 2020). Specifically, we first estimate firm-specific weekly returns. For firm *i* in 2019, we run the following expanded market model regression:

$$R_{i,k} = \alpha_i + \beta_{1,i}R_{m,k-2} + \beta_{2,i}R_{m,k-1} + \beta_{3,i}R_{m,k} + \beta_{4,i}R_{m,k+1} + \beta_{5,i}R_{m,k+2} + \varepsilon_{i,k} \quad (4)$$

Where, $R_{i,k}$ is the return on stock *i* in week *k*; $R_{m,k}$ is the value-weighted market return in week *k*. We include the lead and lag terms for the market index returns to allow for nonsynchronous trading. The firm-specific weekly return for firm *i* in week *τ* ($W_{i,k}$) is calculated as $\log(1 + \varepsilon_{i,k})$, where $\varepsilon_{i,k}$ is the residual return in the above equation.

For *CrashDownUp*, we separate all weeks within the unique firm-year into two groups: “down” weeks and “up” weeks. Specifically, “down” (“up”) weeks are weeks with the firm-specific weekly returns, $W_{i,k}$, below (above) the annual mean. We then construct *CrashDownUp* in 2019 as the natural logarithm ratio of the standard deviation in the “down” weeks to that in the “up” weeks as follows:

$$CrashDownUp_i = \log \left\{ \frac{(n_u - 1) \sum_{down} W_{i,k}^2}{(n_d - 1) \sum_{up} W_{i,k}^2} \right\} \quad (5)$$

Where, n_u and n_d are the number of firm *i*'s up and down trading weeks in 2019, respectively. A higher value of *CrashDownUp* indicates greater stock price crash risk.

Our second measure of stock price crash risk is the negative conditional return skewness (*CrashSkewness*). *CrashSkewness* is defined as the negative of the third moment of the firm-specific weekly returns during 2019 and divided by the standard deviation cubed of the firm-specific weekly returns. For firm *i* in 2019, *CrashSkewness* is calculated as follows:

$$CrashSkewness_i = - \left[\frac{n(n-1)^{3/2} \sum W_{i,k}^3}{(n-1)(n-2) \left(\sum W_{i,k}^2 \right)^{3/2}} \right] \quad (6)$$

Where, *n* is the number of firm *i*'s trading weeks in 2019. A higher value

⁷ This normalized method allows the interaction term coefficient to be directly comparable to the base term coefficients. We also normalize *Leverage*, *DebtGrowth*, *CrashDownUp*, and *CrashSkewness* in the same method.

⁸ 0.006/0.014. We calculate the subsequent economic significance in the same method.

Table 4

Financial stress and short sales in response to local COVID-19 pandemic.

Dependent variable =	<i>ShortRatio</i>			
Independent variable =	<i>Local_COVID19_1d</i>		<i>Local_COVID19_5d</i>	
	(1)	(2)	(3)	(4)
Panel A:				
<i>Independent</i>	0.016*** (8.46)	0.014*** (6.44)	0.013*** (8.17)	0.009*** (4.63)
<i>Independent*CashRatio</i>	−0.008*** (−3.13)	−0.006*** (−2.62)	−0.006*** (−2.74)	−0.004** (−2.26)
Number of obs.	72,228	72,228	72,228	72,228
Adjusted R-squared	0.715	0.718	0.715	0.717
Panel B:				
<i>Independent</i>	0.019*** (11.11)	0.015*** (7.10)	0.014*** (10.00)	0.009*** (4.82)
<i>Independent*InventoryIncrease</i>	0.006** (2.55)	0.005** (2.54)	0.004** (2.28)	0.004** (2.26)
Number of obs.	68,318	68,318	68,318	68,318
Adjusted R-squared	0.472	0.474	0.472	0.474
Panels A–B:				
Controls	No	Yes	No	Yes
Stock-month fixed effects	Yes	Yes	Yes	Yes
Weekday fixed effects	Yes	Yes	Yes	Yes
Time trend	Yes	Yes	Yes	Yes

This table presents whether financial stress influences the relation between local COVID-19 pandemic and short selling. *Independent* represents independent variable *Local_COVID19_1d* in Columns (1) to (2) and *Local_COVID19_5d* in Columns (3) to (4) hereafter. In Panel A, *CashRatio* equals the cash and cash equivalents divided by the total assets in the last year. In Panel B, *InventoryIncrease* equals the change in inventory scaled by total assets. Other specifications are the same as in Table 3. To make the interaction term comparable to the basic term, we normalize *CashRatio* (*InventoryIncrease*) by subtracting the in-sample mean and dividing the difference by the in-sample standard deviation (the same for the following regressions with continuous interaction variables hereafter).

Table 5

Debt and short sales in response to local COVID-19 pandemic.

Dependent variable =	<i>ShortRatio</i>			
Independent variable =	<i>Local_COVID19_1d</i>		<i>Local_COVID19_5d</i>	
	(1)	(2)	(3)	(4)
Panel A:				
<i>Independent</i>	0.016*** (8.66)	0.014*** (6.53)	0.013*** (8.38)	0.009*** (4.74)
<i>Independent*Leverage</i>	0.008*** (3.59)	0.006*** (3.07)	0.004** (2.51)	0.003* (1.91)
Number of obs.	72,228	72,228	72,228	72,228
Adjusted R-squared	0.715	0.718	0.715	0.717
Panel B:				
<i>Independent</i>	0.020*** (11.35)	0.015*** (7.36)	0.015*** (10.30)	0.010*** (5.06)
<i>Independent*DebtGrowth</i>	0.006** (2.34)	0.006** (2.48)	0.004** (2.21)	0.004** (2.48)
Number of obs.	68,318	68,318	68,318	68,318
Adjusted R-squared	0.472	0.474	0.472	0.474
Panels A–B:				
Controls	No	Yes	No	Yes
Stock-month fixed effects	Yes	Yes	Yes	Yes
Weekday fixed effects	Yes	Yes	Yes	Yes
Time trend	Yes	Yes	Yes	Yes

This table presents whether debt influences the relation between local COVID-19 pandemic and short selling. In Panel A, *Leverage* is the total liabilities divided by fiscal year-end market capitalization in the last year. In Panel B, *DebtGrowth* is the annual percent change in total debts in the previous year. Other specifications are the same as in Table 3.

of *CrashSkewness* indicates greater crash risk.

Table 7 shows the empirical results. In Panel A, we use the normalized *CrashDownUp* to construct the interaction term. The coefficient on the interaction term is generally positive in all specifications and different estimation windows. Specifically, the coefficient on *Independent*CrashDownUp* is significant at the 5% level in Column (3) and significant at the 10% level in Columns (1) and (4). In Panel B, we use *CrashSkewness*

Table 6

Vulnerable industries and short sales in response to local COVID-19 pandemic.

Dependent variable =	<i>ShortRatio</i>			
Independent variable =	<i>Local_COVID19_1d</i>		<i>Local_COVID19_5d</i>	
	(1)	(2)	(3)	(4)
<i>Independent</i>	0.013*** (6.19)	0.012*** (5.12)	0.010*** (6.11)	0.007*** (3.59)
<i>Independent*VulnerableInd</i>	0.032*** (4.89)	0.026*** (4.34)	0.022*** (4.13)	0.017*** (3.45)
Number of obs.	73,109	73,109	73,109	73,109
Adjusted R-squared	0.719	0.721	0.719	0.721
Controls	No	Yes	No	Yes
Stock-month fixed effects	Yes	Yes	Yes	Yes
Weekday fixed effects	Yes	Yes	Yes	Yes
Time trend	Yes	Yes	Yes	Yes

This table examines whether the impact of local COVID-19 on short selling is more pronounced in vulnerable industries. *VulnerableInd* is an indicator variable that equals one if the firm belongs to the industry vulnerable to the COVID-19 pandemic and zero otherwise. Other specifications are the same as in Table 3.

to construct the interaction term. The coefficient on *Independent*CrashSkewness* is significant at the 10% level in Columns (3) and marginally insignificant in Columns (1), (2), and (4). Overall, Table 7 indicates that stock price crash risk might exacerbate the association between the local COVID-19 pandemic and short selling.

4.3. Concerns and robustness

4.3.1. Endogenous selection problem

Since short selling in China is under strict regulation, only stocks selected by the CSRC are permitted to be shortable (Feng and Chan, 2016). However, the selection is not random (Hu et al., 2020). We can only observe the selected stocks, which presumably leads to biases in our primary findings. Inspired by Firth et al. (2013), we adopt a Heckman two-stage model to alleviate this endogeneity issue. Specifically, we construct the fraction of shortable stocks in a province where the focal

Table 7

Stock price crash risk and short sales in response to local COVID-19 pandemic.

Dependent variable =	<i>ShortRatio</i>			
Independent variable =	<i>Local_COVID19_1d</i>	<i>Local_COVID19_5d</i>		
	(1)	(2)	(3)	(4)
Panel A:				
<i>Independent</i>	0.017*** (9.14)	0.014*** (6.56)	0.014*** (8.90)	0.009*** (4.78)
<i>Independent*CrashDownUp</i>	0.004* (1.69)	0.003 (1.62)	0.004** (2.04)	0.003* (1.88)
Number of obs.	71,676	71,676	71,676	71,676
Adjusted R-squared	0.704	0.706	0.704	0.706
Panel B:				
<i>Independent</i>	0.017*** (8.79)	0.014*** (6.48)	0.013*** (8.50)	0.009*** (4.69)
<i>Independent*CrashSkewness</i>	0.003 (1.42)	0.003 (1.35)	0.003* (1.70)	0.003 (1.59)
Number of obs.	71,952	71,952	71,952	71,952
Adjusted R-squared	0.708	0.710	0.708	0.710
Panels A–B:				
Controls	No	Yes	No	Yes
Stock-month fixed effects	Yes	Yes	Yes	Yes
Weekday fixed effects	Yes	Yes	Yes	Yes
Time trend	Yes	Yes	Yes	Yes

This table presents whether stock price crash risk influences the relation between local COVID-19 pandemic and short selling. In Panel A, we measure stock price crash risk as *CrashDownUp*, which equals the natural logarithm ratio of the standard deviation in the “down” weeks to that in the “up” weeks in the last year. In Panel B, we measure stock price crash risk as *CrashSkewness*, which equals the negative of the third moment of the firm-specific weekly returns during the year, divided by the standard deviation cubed of the firm-specific weekly returns over the last year. Other specifications are the same as in Table 3.

firm is located as the first instrument (*ShortableFrac_Province*). We posit that regional information (knowledge) transmission and local regulations help a given firm's compliance with the standards of short selling. The more shortable stocks that are in the same province as a given stock, the more likely the given stock is to be qualified for short selling. The second instrument is the fraction of shortable stocks in the same Fama/French 25 size and book-to-market portfolio as a given stock (*ShortableFrac_FF25*). We assume that stocks in the same portfolio are comparable to a given stock. The more firms in the same portfolio as a given firm are shortable, the larger the probability of the given firm being shortable.

In the first stage, we estimate the probability for a given firm to be shortable based on a probit regression model with instruments and firm fundamental information. Panel A of Table 8 shows the results. The coefficients on *ShortableFrac_Province* and *ShortableFrac_FF25* are both positive and statistically significant at the 1% level in Columns (1) to (4), which is consistent with our expectation. Next, we include the inverse Mill's ratio (*InverseMillsRatio*) obtained from the first-stage model into the second-stage model to correct the potential selection bias. Panel B of Table 8 reports the results. We find that the coefficient on *InverseMillsRatio* is not significant, indicating that our results are less likely to be affected by selection bias in our sample period. With the additional inclusion of inverse Mill's ratio, the coefficients on *Local_COVID19_1d* and *Local_COVID19_5d* are all positive and statistically significant at the 1% level. In addition, we do not observe apparent changes in coefficients on *Local_COVID19_1d* and *Local_COVID19_5d*, compared with those in Table 3. Overall, the relation between the local COVID-19 pandemic and short selling is quite robust.

4.3.2. Excluding firms in Hubei Province

The second concern is that our primary result might only exist in Hubei Province (i.e., the most influenced province, the capital city of which is Wuhan). Due to the great number of infected cases in Wuhan, short sellers might principally short firms listed there. To rule out this concern and prove the robustness of our main findings, we exclude stocks

Table 8

Short sales in response to local COVID-19 pandemic based on Heckman selection model.

	(1)	(2)	(3)	(4)
Panel A:	Dependent variable = <i>ShortableDum</i>			
<i>ShortableFrac_Province</i>	1.555*** (26.68)	1.554*** (26.18)	1.557*** (26.72)	1.556*** (26.23)
<i>ShortableFrac_FF25</i>	3.284*** (251.57)	3.142*** (206.13)	3.284*** (251.57)	3.151*** (206.84)
<i>Local_COVID19_1d</i>	−0.001 (−0.18)	0.000 (0.06)		
<i>Local_COVID19_5d</i>			−0.004 (−1.39)	−0.003 (−0.95)
Number of obs.	162,411	162,411	162,411	162,411
Controls	No	Yes	No	Yes
Industry-month fixed effects	Yes	Yes	Yes	Yes
Weekday fixed effects	Yes	Yes	Yes	Yes
Time trend	Yes	Yes	Yes	Yes
Panel B:	Dependent variable = <i>ShortRatio</i>			
<i>Local_COVID19_1d</i>	0.018*** (8.66)	0.016*** (6.72)		
<i>Local_COVID19_5d</i>			0.014*** (8.03)	0.010*** (4.75)
<i>InverseMillsRatio</i>	0.072 (0.15)	0.012 (0.25)	−0.142 (−0.29)	−0.064 (−1.24)
Number of obs.	73,109	73,109	73,109	73,109
Adjusted R-squared	0.712	0.714	0.712	0.714
Controls	No	Yes	No	Yes
Stock-month fixed effects	Yes	Yes	Yes	Yes
Weekday fixed effects	Yes	Yes	Yes	Yes
Time trend	Yes	Yes	Yes	Yes

In this table, we estimate the Heckman selection model and present the regression results of estimating the impact of the local COVID-19 pandemic on short selling. In Panel A, we perform first-stage probit regressions with the dummy dependent variable (*ShortableDum*), which equals one if the firm is shortable on the current trading date and zero otherwise. The instruments used are: *ShortableFrac_Province* defined as the fraction of shortable firms in the same province as a given firm, and *ShortableFrac_FF25*, defined as the fraction of shortable firms in the same Fama/French 25 size and book-to-market portfolio as a given firm. Panel B reports the results for the second-stage regression that includes the Inverse Mill's ratio (*InverseMillsRatio*) as a control. Other specifications are the same as in Table 3.

whose headquarters are listed in Hubei and rerun our baseline regression model.

Results are presented in Table 9. We find that the coefficients on local NCCOVID-19 cases are positive and statistically significant at the 1% level across all columns. In addition, using different estimation windows and specifications, the sign and significance of local NCCOVID-19 cases in this table are all very similar to our baseline results presented in Table 3. Specifically, in the saturated specification with full controls and fixed effects, the coefficient on *Local_COVID19* in the past one day and

Table 9

Short sales in response to local COVID-19 pandemic: excluding Hubei Province.

Dependent variable =	<i>ShortRatio</i>			
	(1)	(2)	(3)	(4)
<i>Local_COVID19_1d</i>	0.020*** (9.69)	0.020*** (8.14)		
<i>Local_COVID19_5d</i>			0.015*** (9.34)	0.013*** (5.90)
Controls	No	Yes	No	Yes
Stock-month fixed effects	Yes	Yes	Yes	Yes
Weekday fixed effects	Yes	Yes	Yes	Yes
Time trend	Yes	Yes	Yes	Yes
Number of obs.	70,692	70,692	70,692	70,692
Adjusted R-squared	0.711	0.714	0.711	0.714

In this table, we perform regression analyses that exclude firms whose headquarters are in Hubei Province for robustness. Other specifications are the same as in Table 3.

five days equals 0.020 and 0.013, respectively. It is intuitive as corporate operations are primarily influenced by the local business environment. The requirements for homeworking, traffic, and commodity control from local governments decrease operating efficiency and impede corporate development. In addition, according to local rules, companies have to cover the costs for maintaining employees' health and safety, such as improving working conditions and daily sterilizing, and face reduced market demand. Overall, the results suggest that the relation between the local COVID-19 pandemic and short selling is prevalent.

4.3.3. Excluding months when firms issue financial reports

The third concern raises a scenario where our primary result might be driven by financial reports, such as 2019 annual reports and 2020 quarterly reports. Specifically, short sellers might anticipate negative reports and short in advance (Christophe et al., 2004) or trade after the disclosure of reports by analyzing public information (Engelberg et al., 2012). If firms issue negative reports in months when the local COVID-19 pandemic happens to be severe, our main finding could be that short sellers react to the negative reports issued by local firms rather than the local COVID-19 pandemic. We exclude months when a firm issues an annual or quarterly report to rule out this possibility.

Results are reported in Table 10. The coefficients on *Local_COVID19* are all positive and statistically significant at the 1% level across all four columns. Our concern is formally tested in Columns (2) and (4) with the inclusion of all control variables and fixed effects. Specifically, the coefficient on *Local_COVID19* equals 0.012 in Column (2) and 0.009 in Column (4), similar to the findings in Table 3. We find no significant difference in the sign, magnitude, and significance after excluding the months with financial reports. Hence, our primary result is robust and not merely driven by financial reports.

4.4. Additional analyses

4.4.1. Analysis based on a quasi-exogenous event

This section examines the impact of a quasi-exogenous event on the relation between local COVID-19 pandemic and short selling. On April 15, 2020, Leishenshan hospital was closed. It was a landmark development in the battle with the pandemic. Hence, we use this event to explore whether this closure reinforces investors' beliefs and consequently influences short sellers. Specifically, we introduce *AfterDum*, an indicator variable that equals one if the trading date is after April 15, 2020, and zero otherwise, into our baseline regression model.

Results are shown in Table 11. To answer the aforementioned question, we additionally include the data of short selling and COVID-19 cases in May 2020, during which there is no nationwide outbreak. We find that the coefficient on *Local_COVID19* is positive and statistically significant at

Table 10

Short sales in response to local COVID-19 pandemic: excluding months with financial reports.

Dependent variable =	ShortRatio			
	(1)	(2)	(3)	(4)
<i>Local_COVID19_1d</i>	0.015*** (7.29)	0.012*** (5.07)		
<i>Local_COVID19_5d</i>			0.013*** (7.32)	0.009*** (4.30)
Controls	No	Yes	No	Yes
Stock-month fixed effects	Yes	Yes	Yes	Yes
Weekday fixed effects	Yes	Yes	Yes	Yes
Time trend	Yes	Yes	Yes	Yes
Number of obs.	52,087	52,087	52,087	52,087
Adjusted R-squared	0.743	0.749	0.743	0.749

In this table, we perform regression analysis that excludes the trading months when firms issue quarterly or annual reports. Other specifications are the same as in Table 3.

Table 11

Lifting the lockdown restrictions and short sales in response to local COVID-19 pandemic.

Dependent variable =	ShortRatio			
	Local_COVID19_1d		Local_COVID19_5d	
Independent variable =	(1)	(2)	(3)	(4)
<i>Independent</i>	0.016*** (8.17)	0.017*** (7.49)	0.011*** (7.17)	0.007*** (3.84)
<i>Independent*AfterDum</i>	-0.020*** (-2.76)	-0.023*** (-3.28)	-0.016*** (-3.83)	-0.018*** (-4.39)
<i>AfterDum</i>	-0.056*** (-7.52)	-0.002 (-0.22)	-0.043*** (-5.50)	0.011 (1.30)
Number of obs.	120,734	120,734	120,734	120,734
Adjusted R-squared	0.661	0.664	0.661	0.664
Controls	No	Yes	No	Yes
Stock-month fixed effects	Yes	Yes	Yes	Yes
Weekday fixed effects	Yes	Yes	Yes	Yes
Time trend	Yes	Yes	Yes	Yes

This table examines the impact of local COVID-19 pandemic on short selling after lifting the lockdown restrictions in Wuhan. *AfterDum* is an indicator variable that equals one if the trading date is after April 15, 2020, and zero otherwise. Other specifications are the same as in Table 3.

the 1% level across all estimation windows and specifications. The result is consistent with our baseline result. To measure the impact of lifting the lockdown restrictions in Wuhan on the relation between the local COVID-19 pandemic and short selling, we construct the interaction term using *Local_COVID19* and *AfterDum*. The coefficient on the interaction term is negative and statistically significant at the 1% level in all columns. The results are consistent with our expectations because this event is significantly cardiotoxic to the whole market. It signifies that life and work will be back on track. As a result, the impact of local COVID-19 pandemic on short selling becomes weaker.

4.4.2. Analysis based on subsequent outbreaks

In this section, we review the relation between local COVID-19 pandemic and short selling in the out-sample outbreaks from June to August to explore whether the impact of the pandemic decays over time. We perform this analysis to provide further evidence about short sellers' reactions to subsequent native COVID-19 outbreaks. Specifically, the second outbreak occurred in Beijing in June.⁹ In late mid-July, a large-scale cluster was reported in Xinjiang.¹⁰

Results are reported in Table 12. In Panel A, we focus on the outbreak in Beijing roughly from June to July. We find a statistically positive relation between the local COVID-19 pandemic and short selling in Columns (1) and (3). However, when we include control variables and fixed effects, the impact of the local COVID-19 pandemic on short selling becomes insignificant. This result suggests that short sellers are not that sensitive to the local COVID-19 pandemic during the Beijing outbreak. Next, we use the outbreak sample in Xinjiang in Panel B. We find no significant relationship between the local COVID-19 pandemic and short selling in all columns. Overall, findings in this section indicate short sellers' indifferent attitude toward the later local COVID-19 pandemic.

5. Conclusion

Numerous studies demonstrate that the COVID-19 pandemic has significantly influenced economic growth and financial markets by using aggregated index returns. However, an underexplored question is how informed and sophisticated investors (e.g., short sellers) react to the local COVID-19 pandemic. We aim to answer the question by using disaggregated daily COVID-19 data related to the location of each listed

⁹ <http://www.chinanews.com/sh/shipin/2020/06-11/news858976.shtml>.

¹⁰ <http://www.chinanews.com/sh/2020/07-16/9239907.shtml>.

Table 12

Short sales in response to local COVID-19 pandemic during subsequent event periods.

Dependent variable =	ShortRatio			
	(1)	(2)	(3)	(4)
Panel A:	Outbreak in Beijing (from 2020 to 06-10 to 2020-07-06)			
Local_COVID19_1d	0.013** (2.08)	−0.004 (−0.67)		
Local_COVID19_5d			0.034*** (6.20)	0.009 (1.56)
Number of obs.	27,033	27,033	27,033	27,033
Adjusted R-squared	0.611	0.619	0.611	0.619
Panel B:	Outbreak in Xinjiang (from 2020 to 07-15 to 2020-08-16)			
Local_COVID19_1d	−0.001 (−0.21)	−0.002 (−0.31)		
Local_COVID19_5d			−0.002 (−0.37)	−0.002 (−0.45)
Number of obs.	37,639	37,639	37,639	37,639
Adjusted R-squared	0.719	0.722	0.719	0.722
Panels A–B:				
Controls	No	Yes	No	Yes
Stock-month fixed effects	Yes	Yes	Yes	Yes
Weekday fixed effects	Yes	Yes	Yes	Yes
Time trend	Yes	Yes	Yes	Yes

This table examines the impact of local COVID-19 pandemic on short selling in the subsequent events. In Panel A, the sample period of the Beijing COVID-19 outbreak is from June 10, 2020, to July 6, 2020. In Panel B, the sample period of the Xinjiang COVID-19 outbreak is from July 15, 2020, to August 16, 2020. Other specifications are the same as in Table 3.

firm. We find that short selling is positively related to local NCCOVID-19

cases. This supports the view that short sellers trade based on the negative information conveyed by local NCCOVID-19 cases. Next, we employ cross-sectional analyses and find that the relation between local COVID-19 pandemic and short selling becomes stronger in firms with poorer financial stress (e.g., lower cash ratios and more increase in inventory investment), higher leverage, and debt growth, in vulnerable industries, and having higher stock price crash risks. Third, we explore the robustness of the relation between local NCCOVID-19 cases and short selling. The results are robust after addressing the endogenous selection problem, excluding the firms located in Hubei Province and the months related to financial report disclosure. Finally, we explore the relation between local COVID-19 pandemic and short selling in the subsequent events. After lifting the lockdown restrictions in Wuhan, the impact of local NCCOVID-19 cases on short selling is alleviated. Moreover, we find that the positive relation between local NCCOVID-19 cases and short selling vanishes in the subsequent outbreak in Beijing and Xinjiang.

Our study provides supportive evidence on the role of short selling and highlights the underlying mechanism to enrich our understanding of the relation between local COVID-19 pandemic and short selling. Furthermore, our findings also imply that people are becoming indifferent about the COVID-19 pandemic in the subsequent outbreaks. However, the increasing number of confirmed cases worldwide indicates that the COVID-19 pandemic has not yet been eliminated. It is still a deadly and extremely contagious virus, requiring great attention from all.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Variable definitions.

Variables	Description
ShortRatio (%)	ShortRatio equals the firm's daily short volume divided by total trading volume on day t as a percentage.
Local_COVID19	To measure a firm's exposure to the local pandemic, we compute recent newly confirmed COVID-19 cases in the province of the firm's headquarters in the past several days as follows: $Local_COVID19_rd_{i,t-1} = \log(1 + LocalCases_{i,t-1} - LocalCases_{i,t-1-\tau})$ where $Local_COVID19_rd_{i,t-1}$ is the newly confirmed local COVID-19 cases in the province where firm i 's headquarters is located from day $t-1-\tau$ to day $t-1$ ($\tau = 1, 5$). $LocalCases_{i,t-1}$ is the number of local cumulative confirmed COVID-19 cases in the province where firm i 's headquarters is located on day $t-1$. We also calculate the cumulative growth in COVID-19 in the past five days for robustness.
Domestic_COVID19	$Domestic_COVID19$ equals the natural logarithm of one plus the number of newly confirmed cases in China in the previous days. Specifically, we calculate $Domestic_COVID19$ as follows: $Domestic_COVID19_rd_{i,t-1} = \log(1 + DomesticCases_{i,t-1} - DomesticCases_{i,t-1-\tau})$ where $Domestic_COVID19_rd_{i,t-1}$ is the newly confirmed COVID-19 in China from day $t-1-\tau$ to day $t-1$ ($\tau = 1, 5$). $DomesticCases_{i,t-1}$ is the number of cumulative confirmed COVID-19 cases in China on day $t-1$.
Overseas_COVID19	$Overseas_COVID19$ equals the natural logarithm of one plus the total number of newly confirmed cases in countries other than China in the past days. Specifically, we calculate $Domestic_COVID19$ as follows: $Overseas_COVID19_rd_{i,t-1} = \log(1 + OverseasCases_{i,t-1} - OverseasCases_{i,t-1-\tau})$ where $Overseas_COVID19_rd_{i,t-1}$ is the newly confirmed COVID-19 in countries other than China from day $t-1-\tau$ to day $t-1$ ($\tau = 1, 5$). $OverseasCases_{i,t-1}$ is the number of cumulative confirmed COVID-19 cases in countries other than China on day $t-1$.
Turnover (%)	Turnover is the average trading volume divided by the total number of shares outstanding from day $t-5$ to day $t-1$ as a percentage.
StockReturn (%)	StockReturn is the average stock return from day $t-5$ to day $t-1$ as a percentage.
Illiquidity	Illiquidity is measured as the average Amihud illiquidity from day $t-5$ to day $t-1$, where Amihud illiquidity equals the average daily absolute return in percentage divided by the dollar trading volume and multiplied by 1,000,000.
PriceRange (%)	PriceRange equals the average of $\frac{prc_high - prc_low}{prc_high}$ from day $t-5$ to day $t-1$ as a percentage, where prc_high (prc_low) is the daily highest (lowest) price.
CrashDownUp	CrashDownUp is defined as the log ratio of the standard deviation in the “down” weeks to that in the “up” weeks.
CrashSkewness	CrashSkewness is the negative of the third moment of the firm-specific weekly returns during the year and divided by the standard deviation cubed of the firm-specific weekly returns.
CashRatio	CashRatio equals the cash and cash equivalents divided by the total assets reported in the 2019 annual report.
InventoryGrowth	InventoryGrowth equals the change in inventory scaled by total assets reported in the 2019 annual report.
Leverage	Leverage equals the total liabilities divided by fiscal year-end market capitalization in 2019.
DebtGrowth	DebtGrowth equals the annual percent change in total debts reported in the 2019 annual report.
VulnerableInd	

(continued on next page)

(continued)

Variables	Description
	<i>VulnerableIndus</i> is an indicator variable that equals one if the firm belongs to the industries vulnerable to the COVID-19 pandemic and zero otherwise. Vulnerable industries include transportation and postal warehouse (G), food, hotel and tourism (H), real estate (E), video entertainment (R), and construction (K) (Xiong et al., 2020).
<i>AfterDum</i>	<i>AfterDum</i> is an indicator variable that equals one if the trading date is after April 15, 2020, and zero otherwise.
<i>VIX</i>	<i>VIX</i> is the daily closing value of the S&P 500 volatility index from day <i>t</i> -5 to <i>t</i> -1.
<i>MktVolatility</i>	The standard deviation of stock market returns in the prior one month.

Appendix B. Robustness tests for main regressions with standard errors clustered at the province level. Table B1

Main regressions with standard errors clustered at the province level.

Dependent variable =	<i>ShortRatio</i>			
	(1)	(2)	(3)	(4)
<i>Local_COVID19_1d</i>	0.018*** (5.10)	0.016*** (3.16)		
<i>Local_COVID19_5d</i>			0.014*** (4.67)	0.010** (2.28)
<i>Domestic_COVID19_1d</i>		−0.000 (−0.12)		
<i>Overseas_COVID19_1d</i>		−0.004 (−0.77)		
<i>Domestic_COVID19_5d</i>				0.009* (1.95)
<i>Overseas_COVID19_5d</i>				−0.003 (−0.23)
<i>Lagged_ShortRatio</i>		0.158*** (5.19)		0.156*** (5.18)
<i>Turnover</i>		0.003** (2.13)		0.003** (2.14)
<i>StockReturn</i>		−0.009*** (−5.15)		−0.009*** (−5.52)
<i>Illiquidity</i>		0.058 (0.91)		0.054 (0.77)
<i>Price range</i>		−0.006** (−2.68)		−0.005** (−2.17)
<i>VIX</i>		0.001 (0.88)		0.001 (1.36)
<i>MktVolatility</i>		2.642*** (3.10)		1.354* (1.80)
Stock-month fixed effects	Yes	Yes	Yes	Yes
Weekday fixed effects	Yes	Yes	Yes	Yes
Time trend	Yes	Yes	Yes	Yes
Number of obs.	73,109	73,109	73,109	73,109
Adjusted R-squared	0.712	0.714	0.712	0.714

This table presents how the firm's exposure to the recent local COVID-19 pandemic affects short selling activities with an alternative clustered method. The dependent variable (*ShortRatio*) is each firm's short selling volume divided by total trading volume on day *t*. *Local_COVID19_1d* and *Local_COVID19_5d* denote the natural logarithm of one plus the number of newly confirmed COVID-19 cases in the province of the firm's headquarters in the past one day and five days, respectively. Other specifications are the same as in Table 3. Variable definitions are available in Appendix A. The *t*-statistics are calculated with standard errors clustered at the province level and reported below the regression coefficients in parentheses. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level (two-sided), respectively.

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